Case study: The utility of combined pulsed and CW muon sources at BNL

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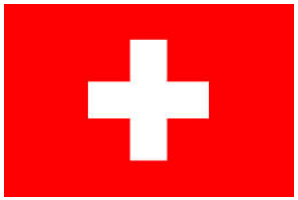
Pulsed and CW muon sources

Continuous Wave



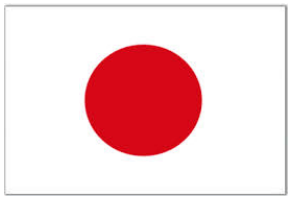
PSI

TRIUMF

- Excellent time resolution (required for fast relaxation, high TF)
- Lower count rate (~5 million events per hour)
- Difficult to get meaningful signal beyond ~10 μs

Pulsed

ISIS



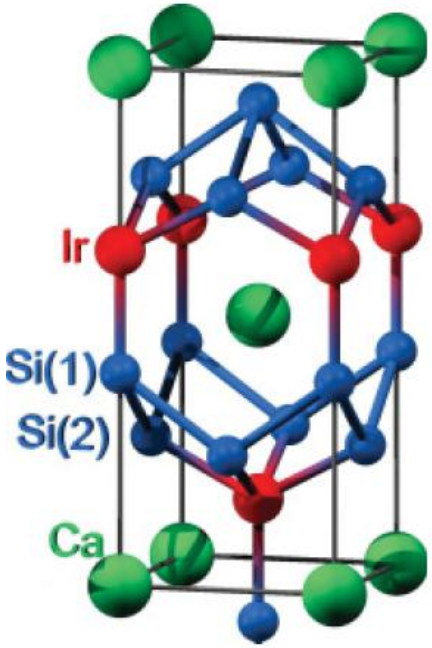
J-PARC

- Limited time resolution due to pulse structure (restricted to TF < 500 G, relaxation < 10 μs^{-1})
- Excellent count rate (~50 million events per hour)
- Can measure to 15-20μs

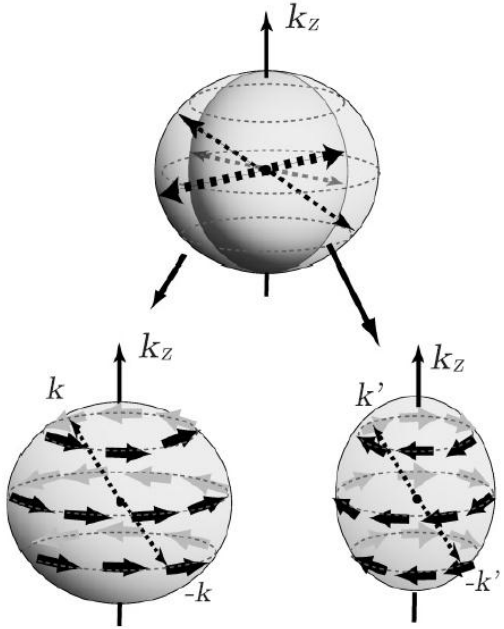
Recent example: Noncentrosymmetric superconductor $CaIrSi_3$

$$\hat{\Delta}_{\boldsymbol{k}} = \{\Delta_1 \psi(\boldsymbol{k}) + \Delta_2 \boldsymbol{d}(\boldsymbol{k}) \cdot \hat{\boldsymbol{\sigma}}\} i\hat{\sigma}_y$$

Nontrivial singlet+triplet gap structure

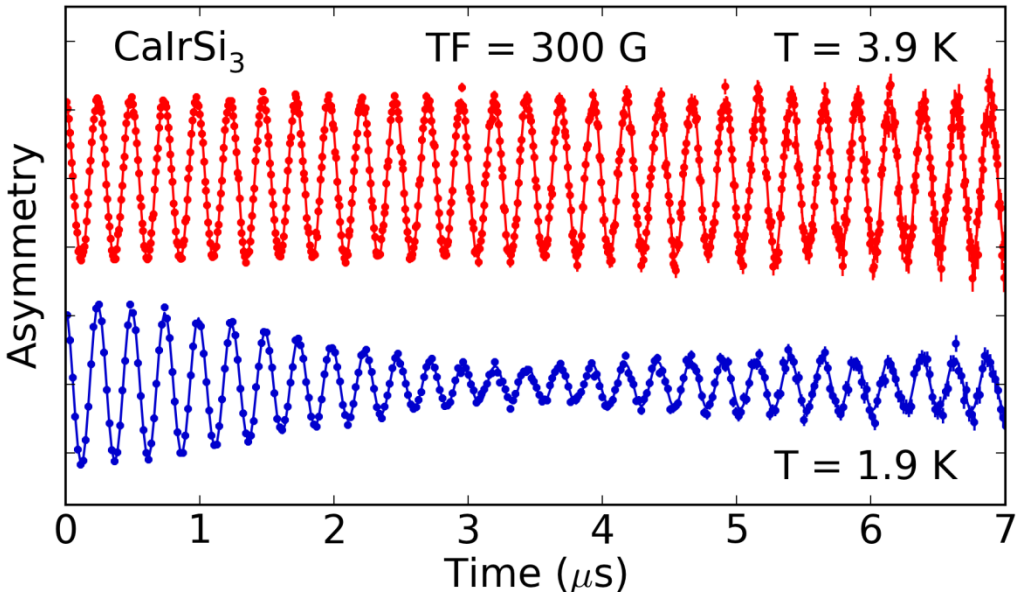


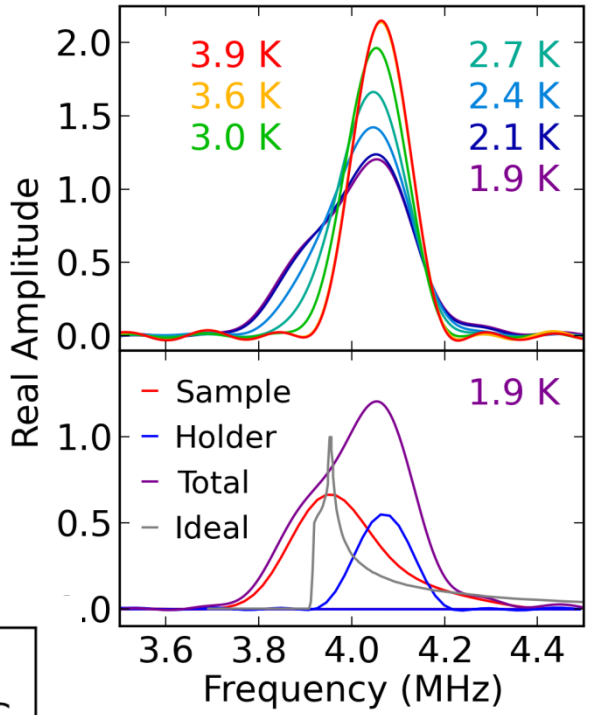
Crystal structure lacks inversion symmetry

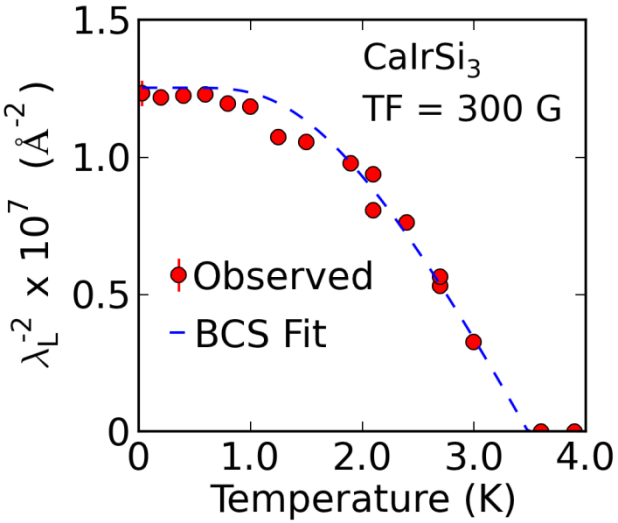


Split Fermi surface due to asymmetric spin-orbit coupling

TF measurements of superfluid density at TRIUMF in summer 2013



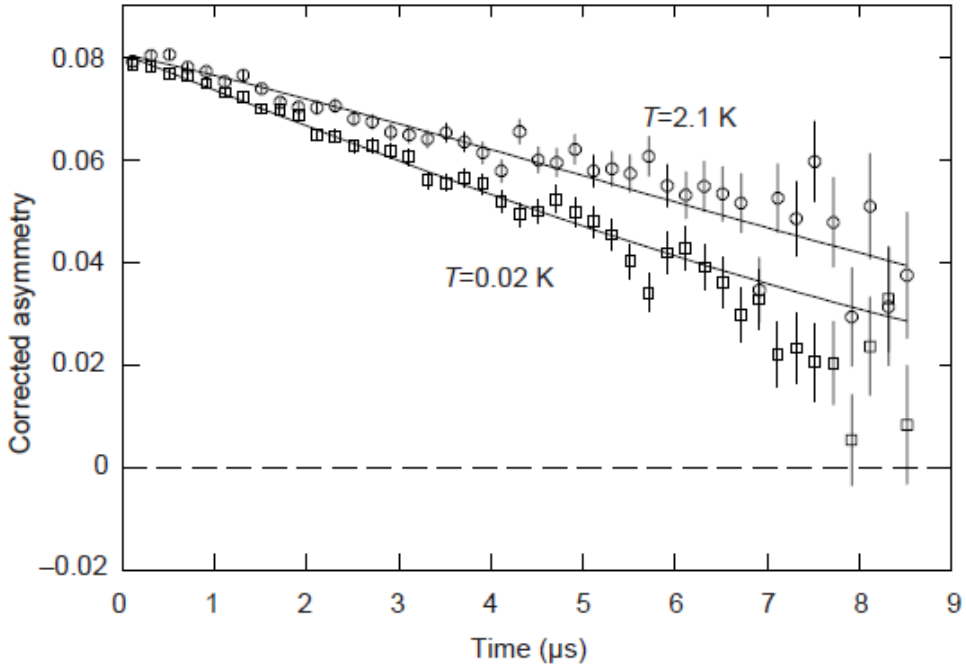


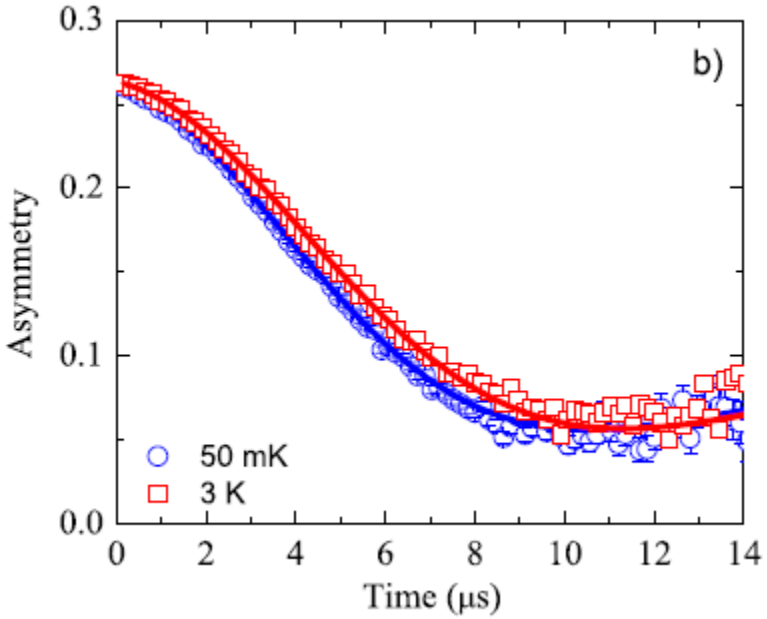


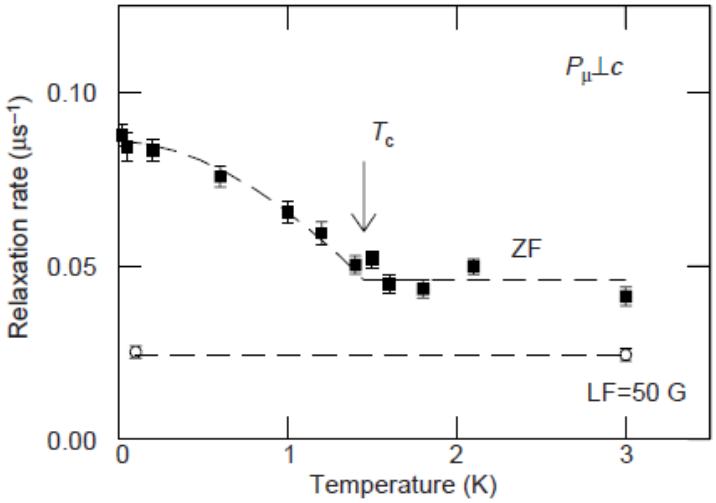
What about time-reversal symmetry breaking?

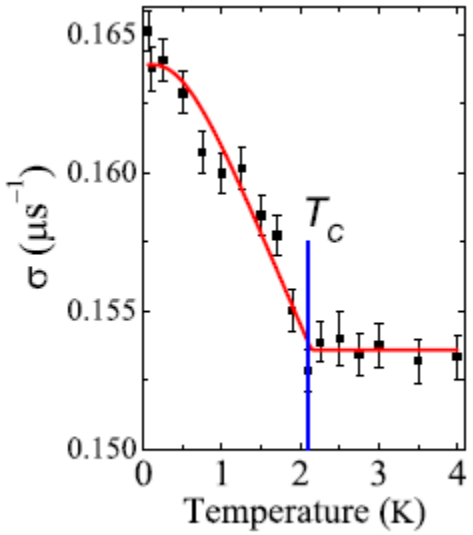
- Spontaneous TRS breaking associated with spin-triplet superconductivity (e.g. Sr_2RuO_4)
- Produces very weak, disordered magnetism
- μSR is one of the only methods directly detecting TRS breaking
- Requires excellent statistics out to long times
- Pulsed muon sources ideal for this type of measurement

Examples of TRS breaking

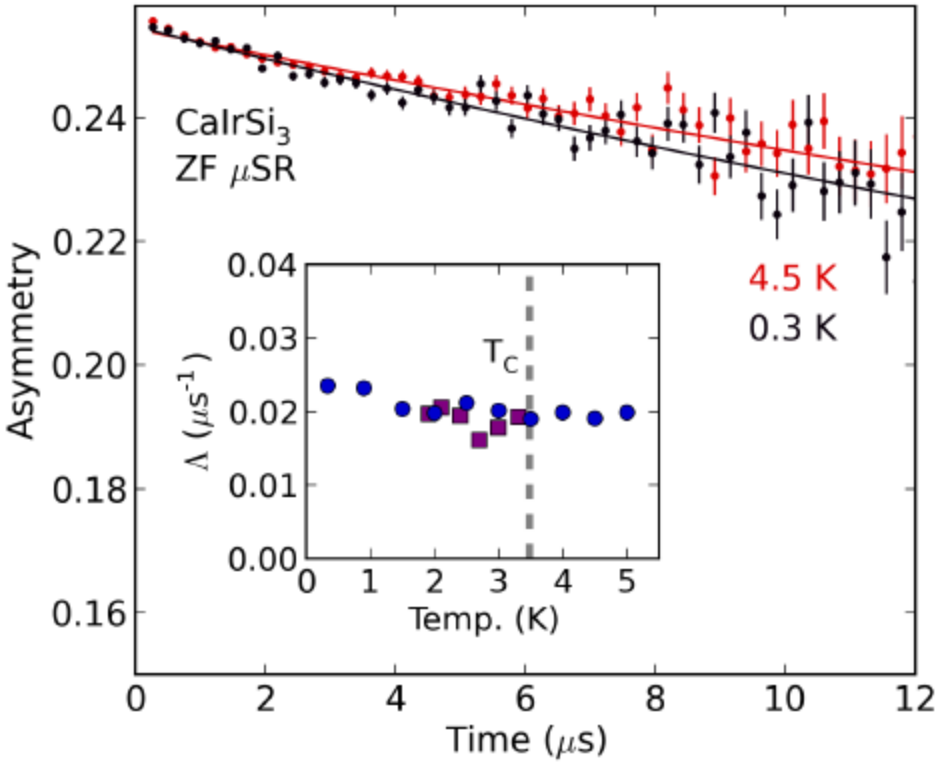








ZF measurements of $CaIrSi_3$ at ISIS in summer 2014



- No TRS breaking
- Noncentrosymmetry of CaIrSi3 does not lead to unconventional behaviors detectable by μSR

Current μSR user facilities

Conclusions

- If you need combined pulsed/CW measurements under the present system:
  - Separate facilities
  - Separate proposals
  - Increased demands on time/money
  - Limits scientific possibilities for air-sensitive samples, specialized environments or in-situ measurements, etc
- Possibility of dual pulsed/CW modes could be unique and highly advantageous feature at BNL